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Sentinel Surveys 1995-2011: Catch per Unit Effort in NAFO Subdivision 3Ps

D. Maddock Parsons

Science Branch
Fisheries and Oceans Canada
P.O. Box 5667
St. John's NL A1C 5X1

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Canada

Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the Secretariat.

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ABSTRACT

Unstandardized catch rates for Sentinel Surveys in Northwest Atlantic Fisheries Organization (NAFO) Subdivision 3Ps are updated for 2010 and preliminary results are given for 2011. Gillnet catch rates (weekly average number of fish per net) in the most recent years remained low compared to 1996-1998 catch rates. Small mesh gillnets typically catch fish in two size ranges (36-44 cm and 52-56 cm) and since 2000, there have been fewer fish in both size modes. Linetrawl catch rates (weekly average number of fish per 1000 hooks) increased from 2000 and showed an increase in the number of fish at the 44-54 cm size range from 2002 to 2004. Linetrawl catch rates since 2000 have been lower than those in 1995-1997, but showed a slightly increasing trend from 2000 to 2008, but were lower in 2009 and 2010. Catch rates in the both gillnet mesh sizes were lower than average from about 2000. Linetrawl catch rates were lower than average from 1999 to 2005, and average during 2006 to 2010.

Trends in liver and gutted body condition showed a seasonal cycle, with condition declining over the winter and early spring, and increasing again over the summer once spawning has occurred. Annually, trends in condition varied over the time series, but declined from 2007 to 2009. In 2010, there were improvements in condition, although a general decline is evident from about the early 2000s. Both length and weight at age have shown general declines in fish older than age 7 since the early part of the time series.

Relevés sentinelles 1995-2011 : prise par unite d'effort dans la sous-division 3Ps de l'OPANO

RÉSUMÉ

Les taux de prise non normalisés des relevés sentinelles effectués dans la sous-division 3Ps de l'Organisation des pêches de l'Atlantique Nord-Ouest (OPANO) sont mis à jour pour 2010, et des résultats préliminaires sont fournis pour 2011. Les taux de prise au moyen de filets maillants (nombre moyen hebdomadaire de prises par filet) est resté faible au cours des dernières années par rapport aux taux enregistrés de 1996 à 1998. En général, les petits filets maillants permettent de capturer des poissons de deux tailles (36-41 cm et 52-56 cm). Depuis 2000, les prises ont diminué dans ces deux catégories. Les taux de prise à la palangre (nombre moyen hebdomadaire de poissons par millier d'hameçons) ont augmenté depuis 2000 et montrent une hausse du nombre de poissons de la taille 44-54 cm entre 2002 et 2004. Depuis 2000, ils sont restés inférieurs à ceux enregistrés en 1995-1997, mais on note une légère tendance à la hausse entre 2000 et 2008, suivie d'un déclin en 2009 et 2010. Les taux de prise pour les deux tailles de filets maillants sont demeurés en dessous de la moyenne depuis 2000 environ. Les taux de prise à la palangre étaient inférieurs à la moyenne de 1999 à 2005 et se situaient dans la moyenne entre 2006 et 2010.

Les tendances en ce qui a trait à l'état du foie et du corps après éviscération montrent un cycle saisonnier, l'état s'affaiblissant au cours de l'hiver et au début du printemps, et s'améliorant à nouveau pendant l'été, une fois la période de fraie terminée. Annuellement, les tendances relatives à l'état varient pendant la période considérée, mais ont montré un déclin de 2007 à 2009. En 2010, on a noté des améliorations de l'état, bien qu'un déclin général est évident depuis le début des années 2000. Tant la longueur que le poids selon l'âge ont diminué d'une manière générale chez les poissons âgés de plus de 7 ans depuis la première partie de la série chronologique.

INTRODUCTION

Sentinel Survey projects were formally announced by the Minister of Fisheries and Oceans Canada (DFO) in October 1994. The Sentinel Surveys in the Newfoundland and Labrador Region of the DFO are an extension of the index fishermen's project from the Northern Cod Science Project Program with modifications to allow for science activities achievable only under a fishing moratorium. Sentinel data collection continued during the commercial/index fisheries that occurred from 1998 to 2002, and in the stewardship fisheries during 2006-2011. Results from previous years have been documented in the Canadian Science Advisory Secretariat (CSAS) research document series (see References).

The Sentinel Survey has the following objectives:

1. To develop a catch rate series for use in resource assessments.
2. To incorporate the knowledge of inshore fish harvesters in the resource assessment process.
3. To describe the temporal-spatial distribution of Atlantic Cod (*Gadus morhua*) in the inshore area over a number of years through, for example, the use of catch rate information, tagging studies, by-catch information and participant's observations.
4. To gather length frequencies, sex and maturity data, and sample ages for use in resource assessment.
5. To provide a source of biological material for other researchers. For example, tissue for genetic, physiological and toxicological analyses, cod stomachs for food and feeding studies, and by-catch information.

MATERIALS AND METHODS

PARTICIPANTS

The primary collectors of data in the Sentinel Survey are inshore fish harvesters. Through consultation with inshore fisher harvesters and fisheries organizations, traditional inshore fishing grounds were identified in the first year of the program.

Fish harvesters from communities within the boundaries of the identified coastal areas and who met eligibility criteria were invited to apply to participate in the survey. Where more than one application was received from an area, the project partner conducted a draw or lottery to select the participant. While there was considerable interest in the project in most areas, there were many sites from which only one application was received and others where additional canvassing was required to enlist participants. Selected participants were required to complete a six-week course designed by the Marine Institute of Memorial University, in consultation with DFO. Topics covered included scientific sampling methods and equipment, computer use, resource assessment basics and presentation skills.

In order to minimize inter-annual enterprise effects on data collection, participants are expected to remain with the survey over a number of years. Sampling activities continued once commercial fishing operations resumed.

SITES

In 2010, 13 enterprises participated in Sentinel activities in Northwest Atlantic Fisheries Organization (NAFO) Subdivision 3Ps, although one participant retired in 2011. The specific location of each site was chosen after consultation between DFO scientists, fish harvesters, and the Fish, Food and Allied Workers Union (FFAW). Site selection was based on the need to survey throughout inshore areas and targeted historical fishing areas and historical gear use patterns.

SAMPLING STRATEGY

Table 1 gives the homeports of participants in the Sentinel Surveys in 1995-2011; showing the number of sets completed in each year and the communities of enterprises participating in the survey. The timing of sampling was determined after discussions with fish harvesters but was targeted for seasonally appropriate times based on historical fishing patterns.

Gillnets and linetrawls were used to survey inshore areas in Subdiv. 3Ps. Cod traps were used to varying degrees from 1998 to 2002 to sample fish, but are no longer used in the Sentinel Survey. Hand lines were used mostly in conjunction with nets or trawls as a means of determining the presence of cod for tagging purposes, or when nets were not catching fish. Hand lines were used to sample cod in several locations and information from this survey was used mainly for biological sampling as catch rate information from hand lining is difficult to interpret.

Hook and line crews fished two tubs of baited linetrawl (approximately 500 hooks per tub) each fishing day. Gillnet crews fished a maximum of six 50-fathom, 5½" monofilament gillnets. Nets were rigged 2-3 to a fleet and up to three fleets were fished per fishing day. In addition, select sites fished one small mesh gillnet (3¼" monofilament) tied to one 5½" gillnet at least 1 day per week. All fish caught in gillnets and on hooks were landed and measured. If catches were too large to sample effectively, the number of nets in a fleet (or number of hooks in the linetrawls) was reduced after consultation with DFO scientists. However, consideration was given to bottom topography and gear performance when decreasing the amount of gear.

Prior to the start of the survey in 1995, a fixed (i.e., control) location on the fishing grounds was established for each site, and will remain fixed for the duration of the Sentinel project. On each fishing day, up to half of the gear was set at the control site. The remainder of the gear (i.e., experimental) was set at one or two other locations on the fishing grounds at the discretion of the participants. The location of each fishing set was plotted on a nautical chart. Start time of the set and soak time for the gear were recorded. Environmental observations were also recorded, including wind direction and speed, percent cloud cover, tide conditions; presence of invertebrates and other fish species in the area (e.g., bait), marine mammals, sea birds and any other variables that might have influenced fishing behavior were also noted. For several years select sites were equipped with a CTD (conductivity-temperature-depth) device which measures water temperature and salinity at depth. At these locations, CTD casts were conducted in the vicinity of fishing sets each fishing day. CTD locations were fished for subsequent years when possible.

When gear was retrieved, catches from control and experimental gear were kept separate and sampled on shore. All fish from gillnet, hand line and linetrawl, and a sample of the catch from traps, were measured for total length and sex. Otoliths were sampled on a fish length-stratified basis and stored in manila envelopes labeled with relevant information. Selected participants collected a length-stratified sample of up to 100 frozen fish on a biweekly basis for detailed biological sampling at DFO's Northwest Atlantic Fisheries Center, St. John's, Newfoundland.

Detailed weight analysis measurements were taken on these samples and condition indices were calculated using:

Fulton's condition factor (K_s) = gutted weight (g) x length $(cm)^3$

Hepatosomatic Index (HSI) = liver weight (g) x gutted weight $(g)^{-1}$ x 100

Gonadosomatic Index (GSI) = gonad weight (g) x gutted weight $(g)^{-1}$ x 100.

Other biological samples were collected when requested. Since 2005, species other than cod have been recorded and measured as well, and this by-catch information is presented as number of fish caught per day (control and experimental sets combined).

RESULTS

Table 2 and Fig. 1 summarize Sentinel activity by gear type from 1995 to 2011; including the number of sets of gear (Nhauls), the total number of fish caught (Nmeas), and the number of sets with no fish (Nzero). The number of gillnet sets declined in 2003, but has remained relatively stable since then. Linetrawl effort in Subdiv. 3Ps declined from 1995 to 1999 and has varied between 180 and 400 sets per year since.

Thirteen enterprises continued to collect information in 2010 although in 2011 there were twelve participants. Each enterprise involved surveyed for 10 weeks in most recent years. Survey timing varied at each location as per traditional fishing seasons.

Figure 2 shows overall average catch per unit effort (CPUE) from 1995 to 2011 for the three main gear types used in Sentinel activity. Gillnet (5½") catch rates were highest in 1997, declined rapidly to 2000 and have been stable at a lower level since. Small mesh (3¼") gillnet catch rates showed a similar trend, decreasing from 1996 to the early 2000s, and since then, fluctuating at lower levels. Both gillnet series have been below their series average from 2000 to present. The gear's ability to catch two distinct size ranges of fish could mask trends in either size group from year to year. Linetrawl catch rates were more variable, and although catch rates decreased from 1996 to 2000, they gradually increased to 2006 to be above the series average. From 2006 to 2010, there was a decline in catch rate, but in 2011 levels have increased and are about average. It should be noted that these overall catch rates may be affected by changes in the number and location of sampling sites as participants leave the survey, or are replaced.

Figures 3-5 give mean CPUE (number of fish per net or 1000 hooks) for the three gear types used in the Sentinel Survey over the entire time series (1995-2011). Catch rates in 5½" gillnet (Fig. 3) were about 10-20 fish per net in most locations with Little Harbour East and North Harbour showing higher catch rates than other areas. Three locations showed lower than average mean CPUE in 2010 and 2011, four locations were about average and only Red Harbour had higher mean CPUE in 2010, but lower for 2011 to date. Figure 4 gives mean CPUE for small mesh gillnet and Little Harbour East and North Harbour again showed higher catch rates over the time series. Wide error bars for both gillnet series show the catch rates in these gears to be more variable over the time series than those in linetrawl (Fig. 5). For linetrawl, mean series catch rates were generally less than 250 fish per 1000 hooks, with Lord's Cove having higher mean CPUE than other areas. All linetrawl sites in 2010 and 2011 were below the time series average, with the exception of Burgeo in 2011 when catch rates were higher than average and Ramea, where catch rates were at the time series average in the most recent two years.

Length frequencies are shown in Fig. 6 as proportion at length by gear type. The 5½" gillnet frequencies show the narrowest range of size selectivity (about 50-80 cm). Given the highly selective nature of this gear, frequencies are generally the same shape from year to year. Small

mesh gillnet (3¼" mesh) caught primarily smaller fish (in the 35-48 cm range) but also picked up a second mode of fish in the 50-65 cm range. Changes in size distribution were difficult to detect in this gear due to its limited selection pattern. Linetrawl had the widest range of size selection of the three gear types used in the Sentinel Survey, capturing fish from about 30 cm to 70 cm. Changes in size distribution of fish were detected in this gear more readily and a shift toward larger fish from 2003 to 2006 and then smaller fish were more evident in 2007 and 2008.

At several locations in Subdiv. 3Ps, fish were sampled for detailed biological information. Data on body condition (K_s), liver condition (HSI), gonad condition (GSI), length and weight at age were compiled for monthly and annual trends. Liver (hepatosomatic index; HSI) and gutted body condition (Fig. 7) cycled seasonally, as did the gonadosomatic index (GSI) for both males and females. GSI increased from January to June, in females, as the ovaries enlarged in preparation for spawning, and decreased over the spawning season (April to October) to a low value in October. Both liver and body condition were lowest in April/May and were highest from September to December. Annually, condition (K_s) showed a general decline in both sexes from the mid-1990s to 1999, then increased to 2003. Condition then was variable year to year, but still showed a general downward trend to 2009, when lowest condition was noted in males and second lowest in the series for females.

Mean length and weight at age (bias corrected for sampling stratification) for cod sampled from the Sentinel Survey are plotted in Fig. 8-11. Both length and weight at age have declined in older fish (age 8 and older) since the early part of the time series. Although trends were similar, cod sampled from linetrawl showed a lower weight and length at age than those sampled from gillnets (Fig. 9 and 11). These differences may be related geographic separation as linetrawl is used predominantly to the west of the Burin Peninsula but may also point to growth differences between subcomponents of the Subdiv. 3Ps stock.

By-catch information was presented as total number of fish caught incidentally in sentinel gear for each year. In gillnet, American Paice (*Hippoglossoides platessoides*), Winter Flounder (*Pseudopleuronectes americanus*), and redfish (*Sebastes* sp.) were the main by-catch species, while linetrawl caught a wider range of species including mainly plaice, redfish, wolffish (*Anarhichas* sp.), skate, Pollock (*Pollachius virens*), and Haddock (*Melanogrammus aeglefinus*) (Fig. 12 and 13).

Given the large spatial coverage of the survey and the differences in timing of the survey between locations, relating observations on catch rate to changes in population dynamics of Atlantic Cod requires standardizing the data for time and location effects. These analyses were undertaken and reported in Healey et al. (2011), and in the Science Advisory Report for Subdiv. 3Ps (DFO 2011). Overall, gillnet catch rates remain low; below average for both the 3¼" mesh and 5½" mesh time series. Linetrawl catch rates were average. In general, trends in the unstandardized data were in agreement with results from the analyses that took time and location into account.

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Table 1. Number of Sentinel Survey sets (all gears) 1995-2011. Data collection for 2011 is ongoing.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
St. Bride's	160	84	74	80	2	52	63	79	59	49	61	64	70	63	49	30	19
Placentia		41															
Fox Hr	145	88	71	71	36	48	60	60	48	54	54	54	60	60	60	60	6
Fairhaven								71									
Little Hr East	157	48	53	48	10	56	67										
Arnold's Cove	151	63	69	27	7	42											
North Hr	114	73	67	50	19	73	55	42	45	30	55	50	54	43	46	61	10
Monkstown	145	69	72	72	36	57	60	60									
Little Paradise	60	50	51	51	36	49	69	64	42	58	52	56	66	58	63	48	56
Red Hr	41	36	40	37	20	32	33	57	22	33	36	34	41	34	32	40	17
Lawn		57	69	71	36	64	78	80	36	72	68	72	59	54	40	36	4
Lord's Cove	54	48	61	50	36	48	61	82	47	70	69	68	80	80	79	80	24
Grand Bank							60	59	38	44	43	42	42	46	46	46	11
Rencontre East	174	96	69	74	36	90	71	60	20	32	40	36	36	36	36	36	
Hr Breton	154	39	27	28	32	45	31	53	34	30	33	40	30	38	34	37	4
Seal Cove	199	71	44	42	33	58	46	48	9								
Francois	181	66	74	68	30	52	35	30	25	10	42	38	28	32	22	27	
Ramea	201	46	96	60	38	88	92	88	46	36	44	44	49	50	48	48	32
Burgeo		46	60	62	28	36	64	45	36	24	28	44	40	36	41	40	8

Table 2. Set details for Sentinel Survey activity in NAFO Subdivision 3Ps from 1995 to 2011. Nhauls=number of sets; Nzero=number of sets with no fish; Nmeas=number of fish measured. Data for 2011 are preliminary.

Gillnet 3 1/4"			
Year	Nhauls	Nzero	Nmeas
1995	2	0	34
1996	10	0	1421
1997	22	1	2544
1998	29	1	1829
1999	6	1	233
2000	48	6	1393
2001	62	6	1831
2002	88	8	1913
2003	47	1	687
2004	60	6	1351
2005	60	8	723
2006	61	5	1067
2007	63	3	664
2008	54	1	848
2009	46	7	674
2010	52	1	1000
2011	35	0	219
Gillnet 5 1/2"			
Year	Nhauls	Nzero	Nmeas
1995	760	216	37776
1996	412	10	40221
1997	459	5	44771
1998	525	14	31163
1999	234	16	6329
2000	424	64	5578
2001	497	37	5720
2002	499	64	4958
2003	246	37	1648
2004	303	33	2560
2005	330	50	2556
2006	327	30	2823
2007	360	25	4027
2008	317	27	3695
2009	313	60	2682
2010	317	49	2985
2011	112	5	936
Linetrawl			
Year	Nhauls	Nzero	Nmeas
1995	1147	55	74813
1996	555	4	61839
1997	467	4	36548
1998	315	4	20521
1999	194	13	9536
2000	407	25	19148
2001	376	28	18274
2002	385	13	21224
2003	214	14	11612
2004	179	6	9301
2005	235	3	11341
2006	254	6	19470
2007	232	5	13295
2008	259	7	15979
2009	237	8	12241
2010	220	22	9144
2011	44	0	2666

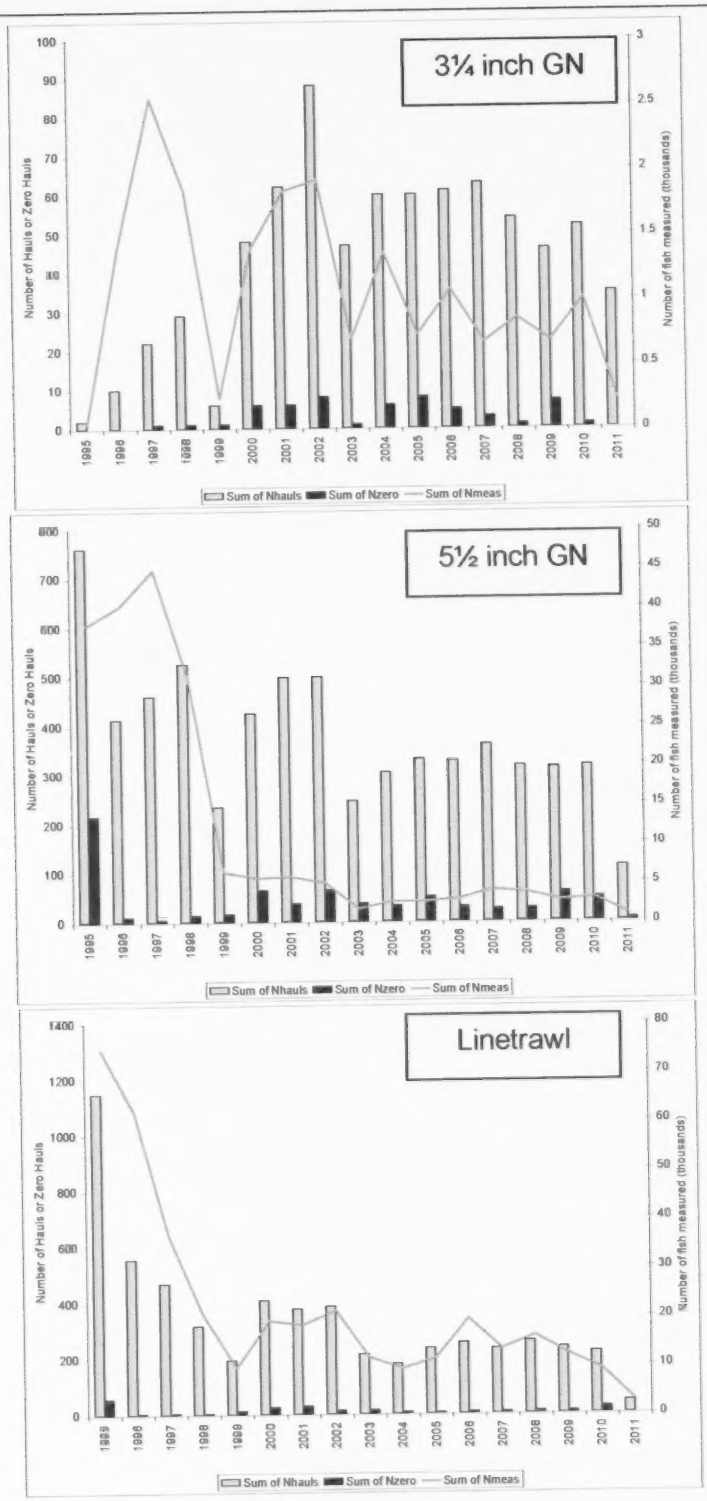

Figure 1. Summary information for Sentinel Survey activity in NAFO Subdivision 3Ps from 1995 to 2011. Nhauls= number of sets; Nzero= number of sets with no fish; Nmeas= number of fish measured. Data for 2011 are preliminary.

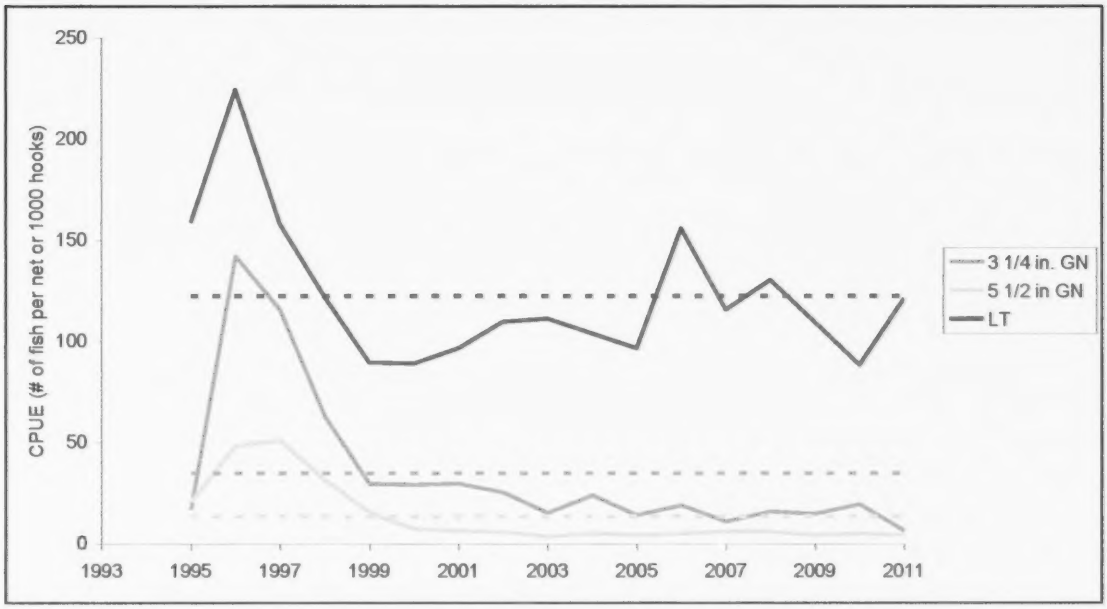

Figure 2. Average number of fish per net (gillnet; GN) or 1000 hooks (linetrawl; LT) caught in Sentinel Surveys (control and experimental gear) for NAFO Subdiv. 3Ps 1995-2011. Dashed lines are series means. Data for 2011 are preliminary.

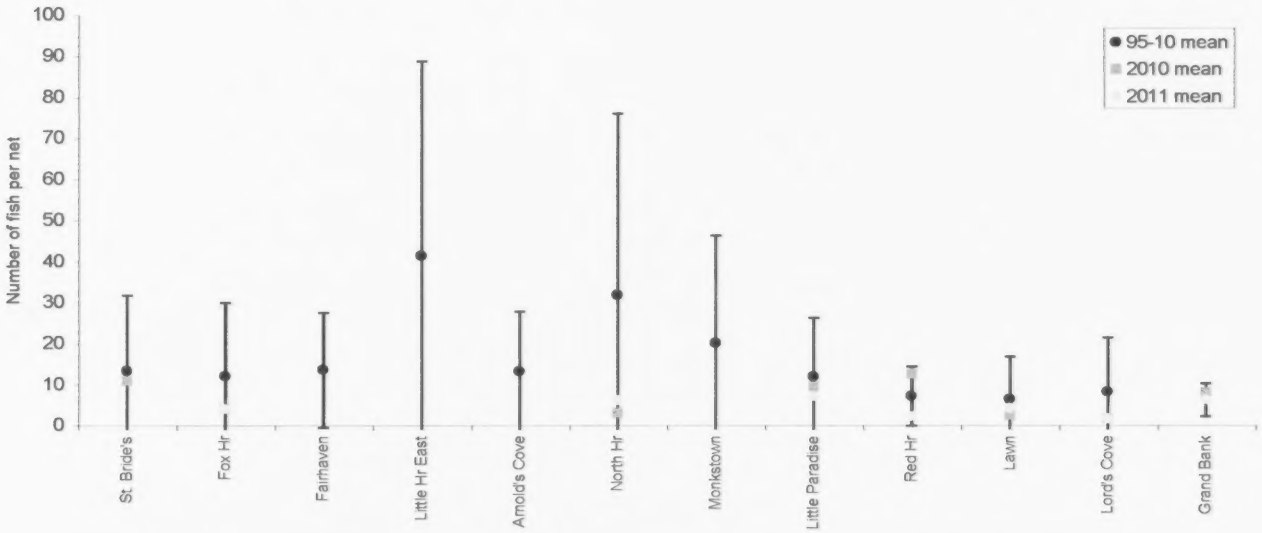

Figure 3. Mean CPUE (number of fish per net) ± 1 standard deviation for Sentinel 5½" gillnet for 1995-2011 with mean CPUE for 2010 and 2011 overlaid. Data for 2011 are preliminary.

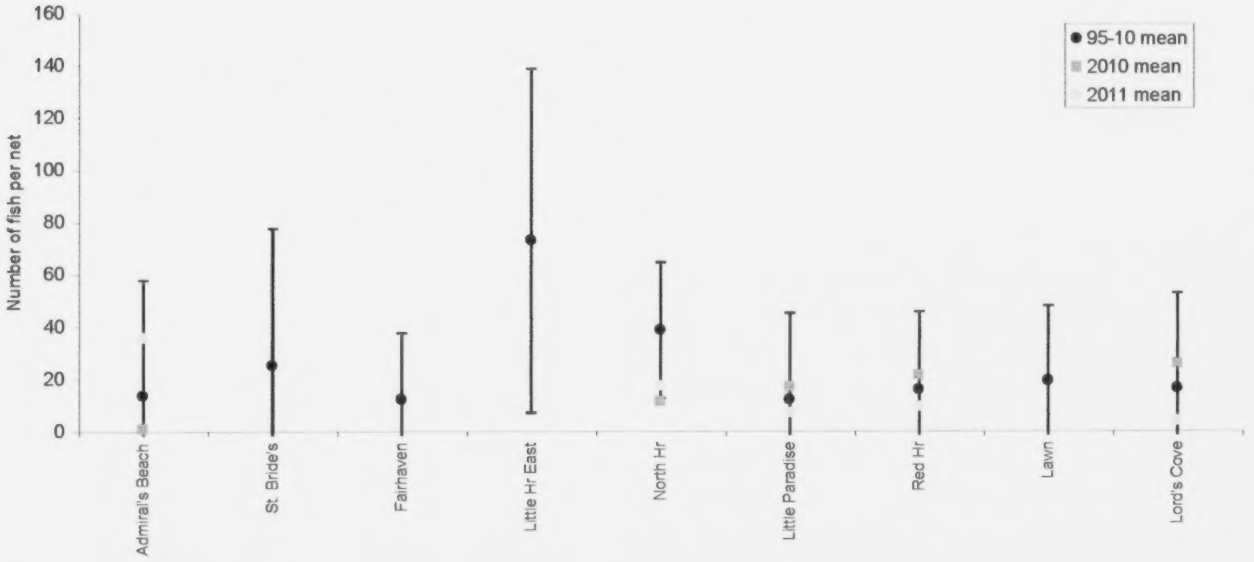

Figure 4. Mean CPUE (number of fish per net) ± 1 standard deviation for Sentinel 3¼" gillnet for 1995-2011 with mean CPUE for 2010 and 2011 overlaid. Data for 2011 are preliminary.

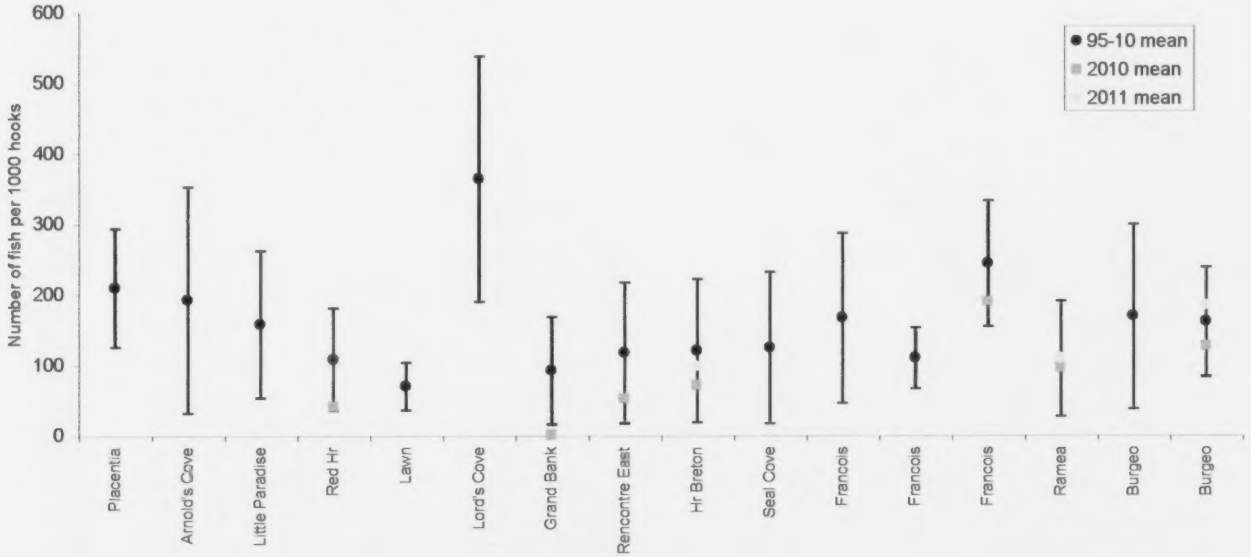

Figure 5. Mean CPUE (number of fish per 1000 hooks) ± 1 standard deviation for Sentinel linetrawl for 1995-2011 with mean CPUE for 2010 and 2011 overlaid. Data for 2011 are preliminary.

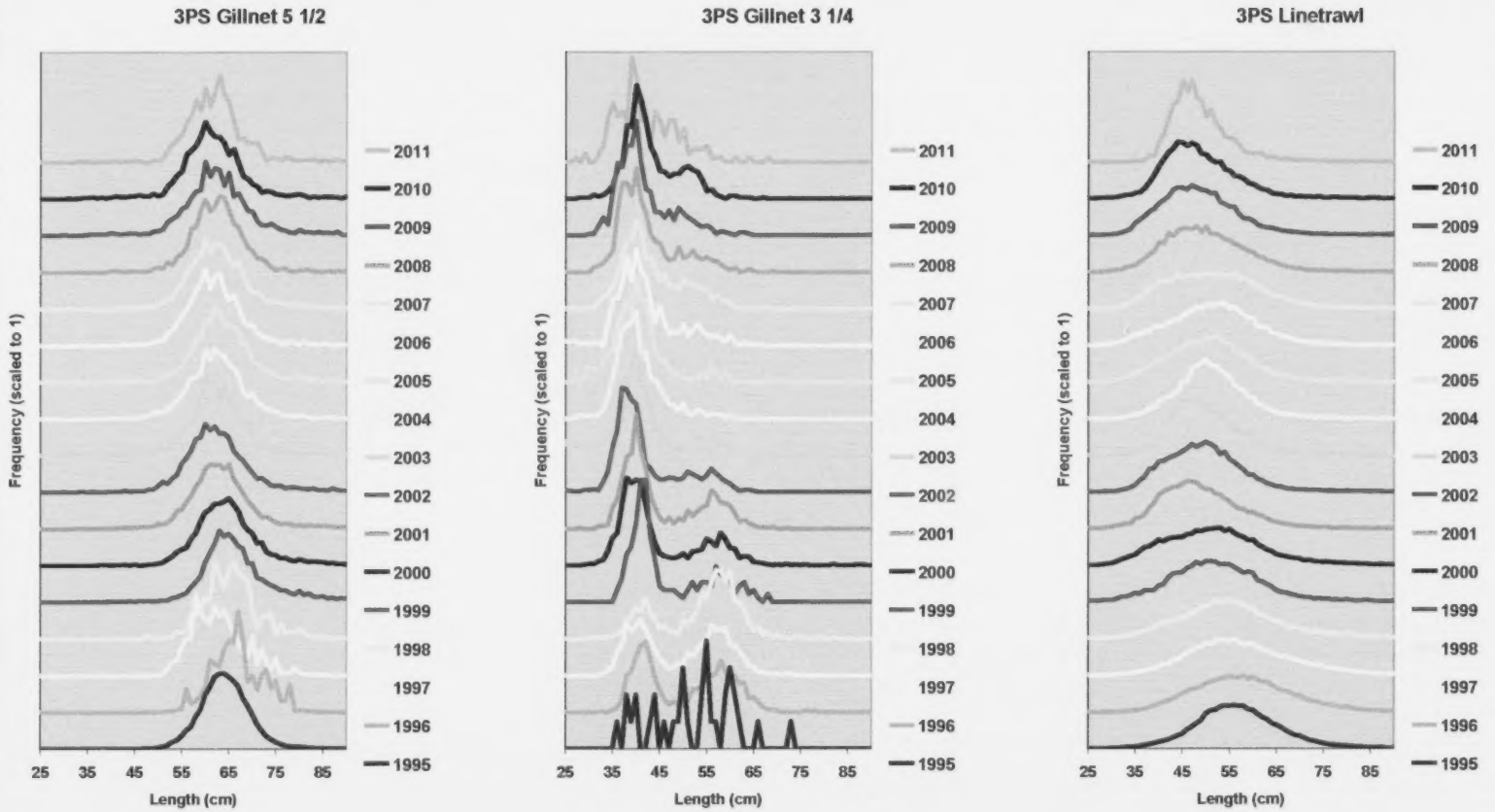

Figure 6. Length frequencies (number at length scaled to 1) of cod caught in Sentinel Surveys (control and experimental gears) from 1995 to 2011 in NAFO Subdiv. 3Ps. Data for 2011 are preliminary.

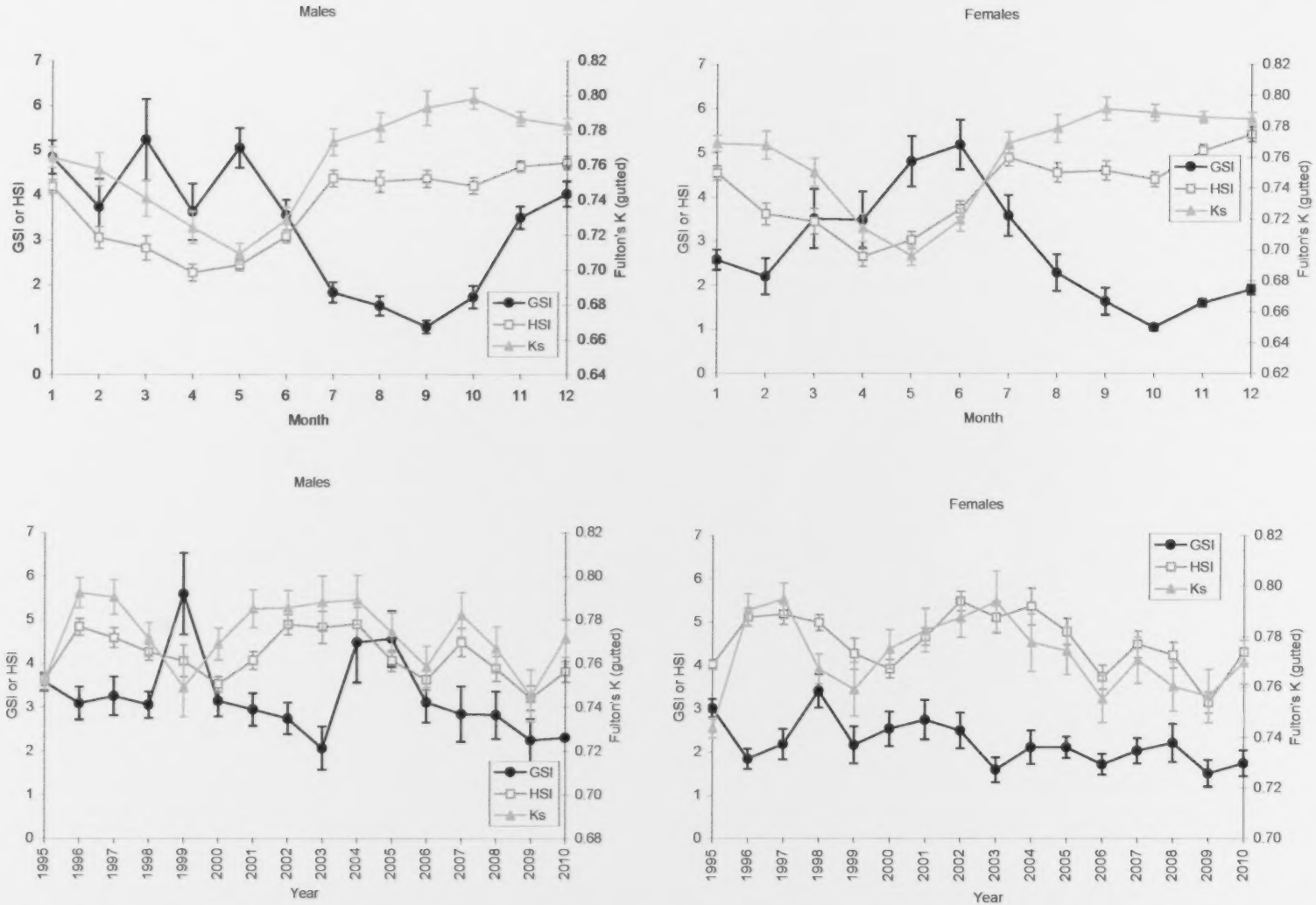

Figure 7. Gonadosomatic index (GSI), hepatosomatic index (HIS), and Fulton's gutted condition factor (K_s) by month and year for cod sampled in Sentinel Surveys in NAFO Subdiv. 3Ps. Data plotted are mean ± 2 S.E.

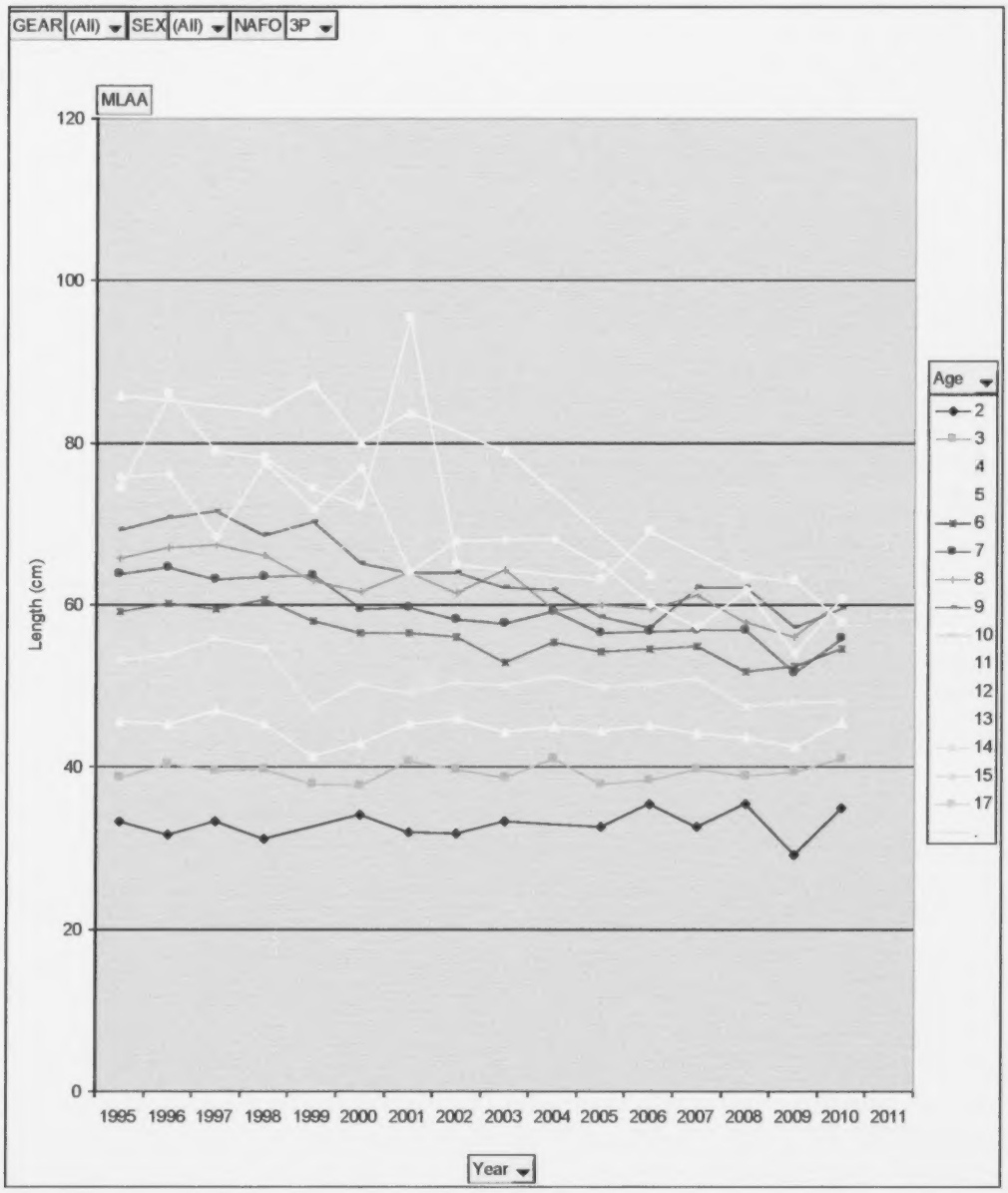

Figure 8. Mean length (cm) at age for cod sampled in Sentinel Surveys in NAFO Subdiv. 3Ps, 1995-2010. Means are corrected for sampling bias.

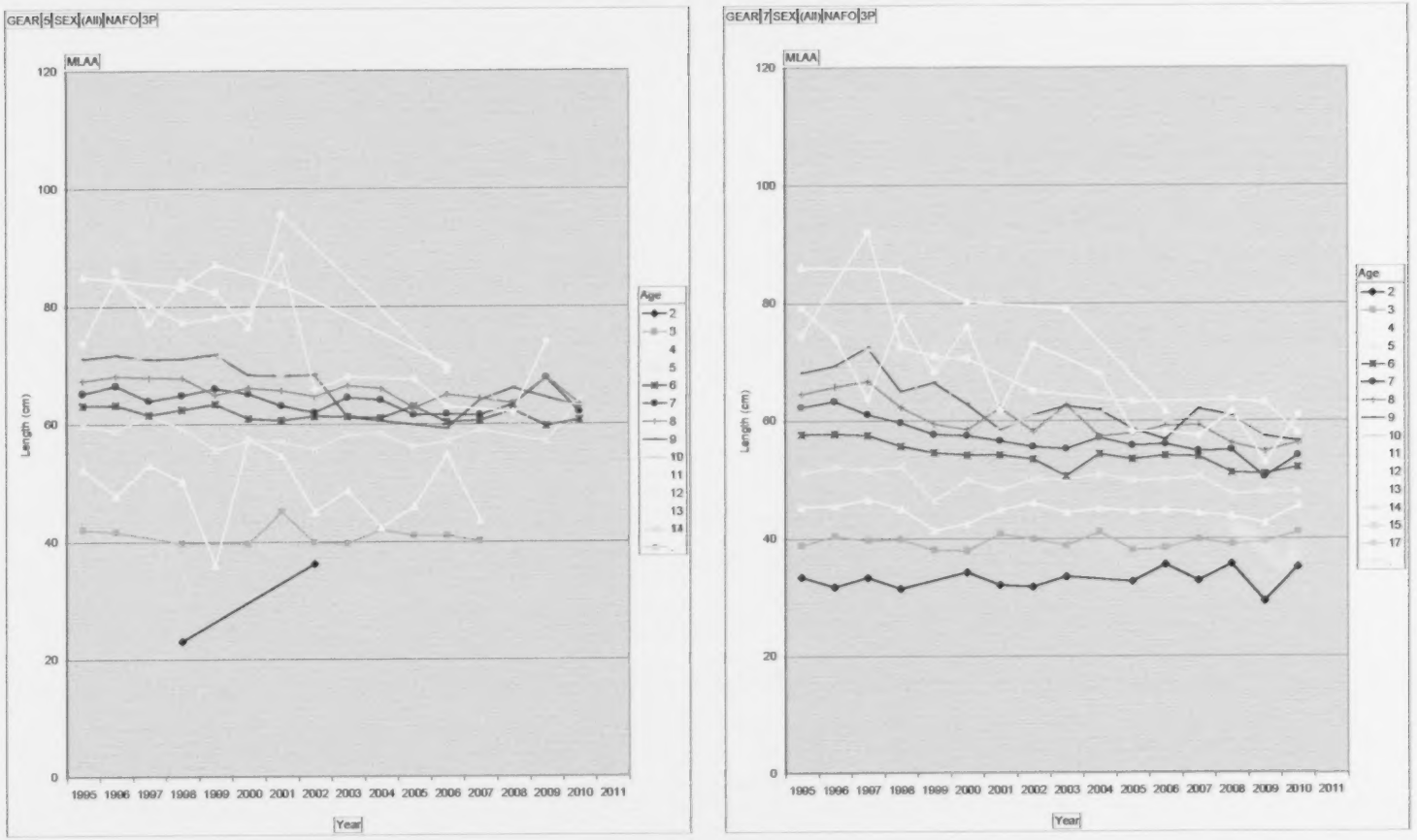

Figure 9. Mean length (cm) at age for gillnet (left panel) and linetrawl (right panel) for cod sampled in Sentinel Surveys in NAFO Subdiv. 3Ps, 1995-2010. Means are corrected for sampling bias.

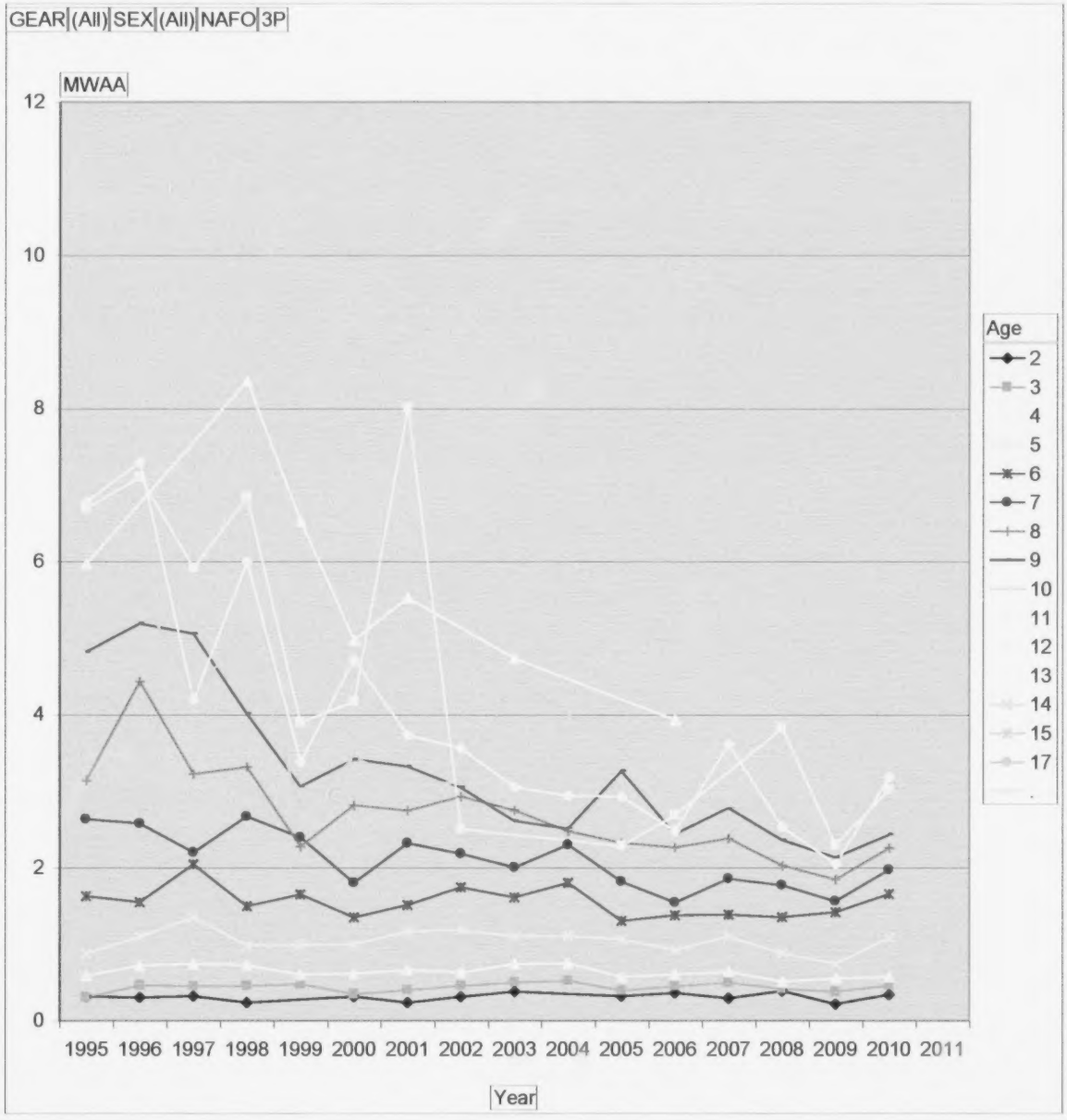

Figure 10. Mean weight (kg) at age for cod sampled in Sentinel Surveys in NAFO Subdiv. 3Ps, 1995-2010. Means are corrected for sampling bias.

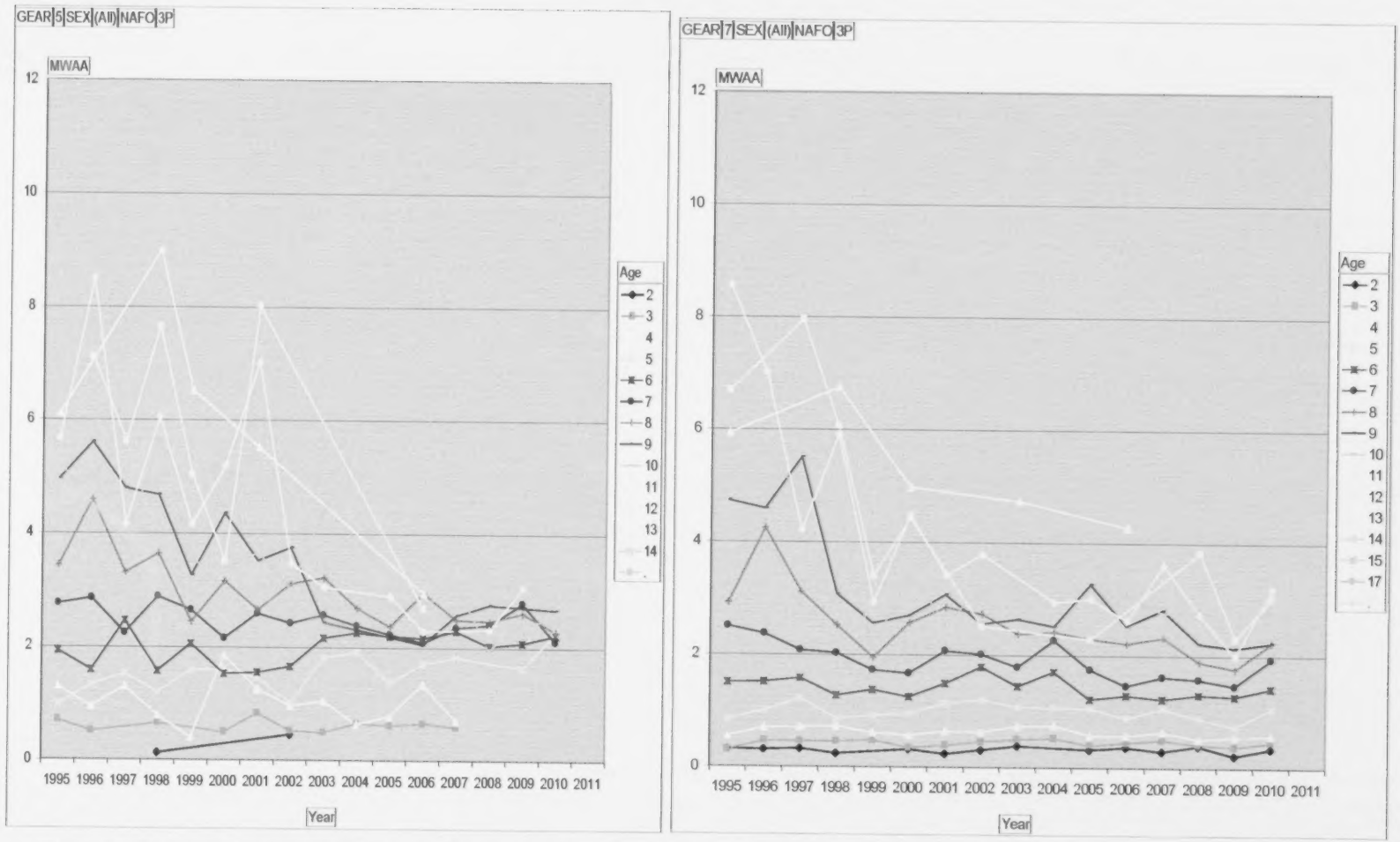

Figure 11. Mean weight (kg) at age for gillnet (left panel) and linetrawl (right panel) for cod sampled in Sentinel Surveys in NAFO Subdiv. 3Ps, 1995-2010. Means are corrected for sampling bias.

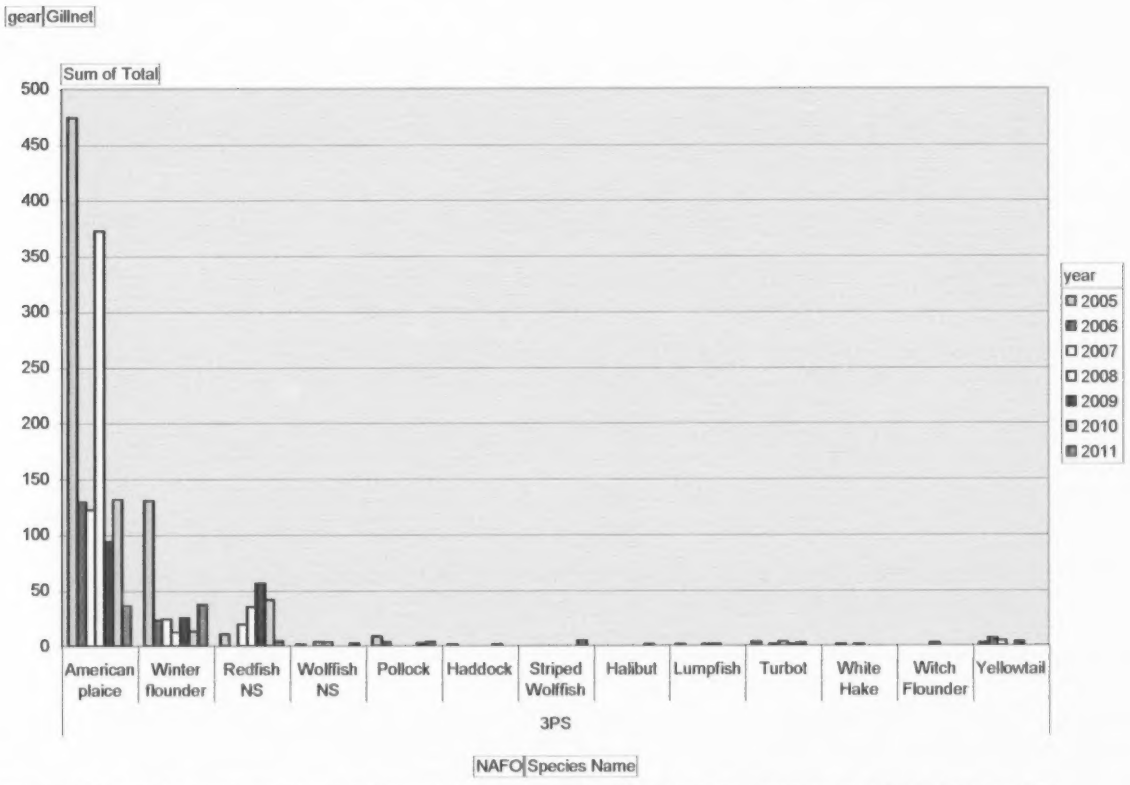

Figure 12. Total annual numbers of by-catch species caught in Sentinel gillnets in NAFO Subdiv. 3Ps from 2005 to 2011.

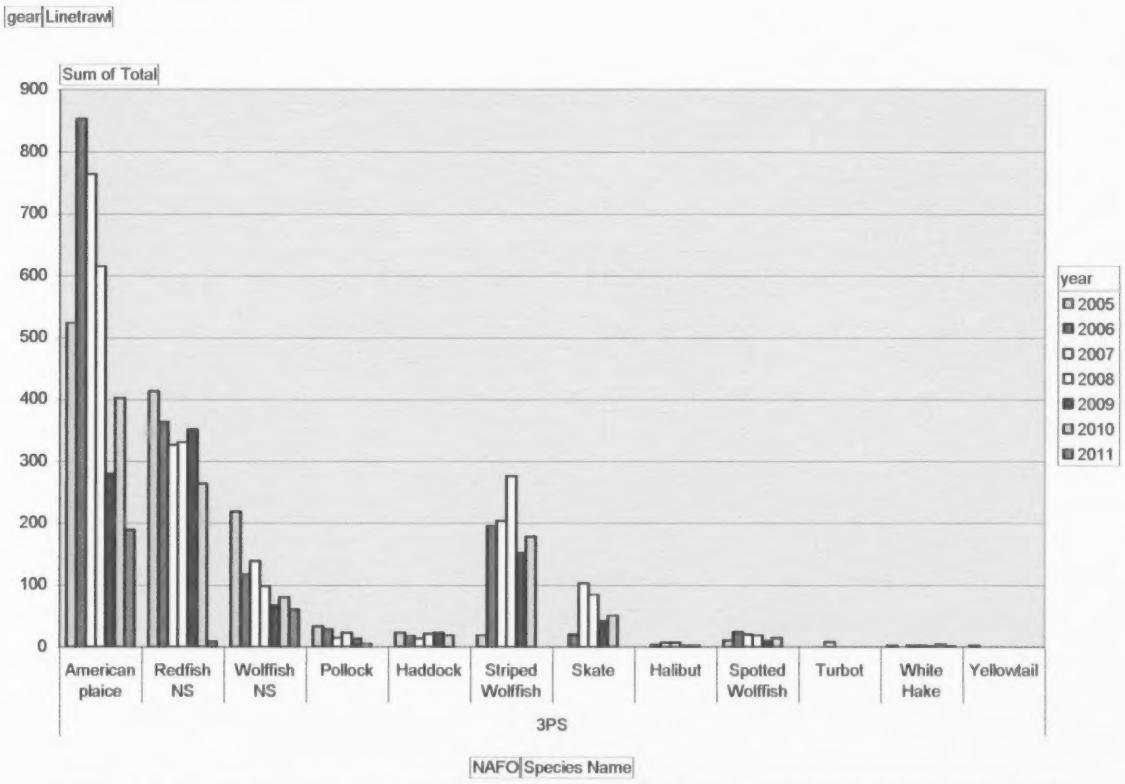

Figure 13. Total annual numbers of by-catch species caught in Sentinel linetrawl in NAFO Subdiv. 3Ps from 2005 to 2011.